Similarities and Differences

Between X-ray Analysis

And

Computerized Fixation Imaging of the Cervical Spine

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ABSTRACT

This paper presents a comparative study of the results of x-ray analysis and Computerized Fixation Imaging (CFI) analysis of the cervical spine. Twenty-five patients seeking chiropractic care at a private clinic were randomly selected to participate in the study.

This study was undertaken to answer questions from clinicians using the Sense Technology PulStarFRAS (Function Recording and Analysis System). These questions arise regarding the findings of a mature and widely used method of spinal analysis (x-ray) and this new and rapidly evolving method of objective instrumented palpation (CFI).

Significant major findings were:

- A Kendall coefficient of concordance of .74 was obtained between the results of x-ray analysis and the results of CFI analysis.
- A Kendall coefficient of concordance of .74 was obtained between x-ray findings of arthritic joint involvement and CFI analysis and
- A Kendall coefficient of concordance of .76 was obtained between x-ray findings of discontinuities of cervical spine curvature and CFI analysis.

These results show that there is a high degree of correlation between x-ray analysis and CFI in findings of discontinuities of spinal structure and in observation of evidence of osteo-arthritis.

INTRODUCTION

This study was undertaken to address questions raised by practitioners regarding the differences between a relatively old and established method of spinal analysis (x-ray analysis) and the recently introduced CFI methodology. X-ray analysis of spinal segments has been used by the chiropractic profession and others to assist in the development of rehabilitation protocols since the early 1900's.[1]

Computerized Fixation Imaging (CFI) is a method of joint function analysis that consists of comparing the mobility of two or more joint segments. The comparison is made by challenging each joint segment in turn with a low energy mechanical impulse and measuring the response. The response of the joint is a measure of the resistance to movement of the joint and is presented as a graph of the relative compliance of the joints tested. Low compliance (high resistance to motion) of a joint is interpreted as joint fixation. The method is referred to as "Computerized Fixation Imaging" since the compliance data is stored as a vector (or "image" in mathematical terminology) and is presented to the user on a computer screen as a graph.

Since Computerized Fixation Imaging is a non-invasive methodology that uses no ionizing radiation, it may be used at any time during the course of patient management. While x-ray is a direct image of the spinal structure, CFI produces an indirect image in the form of a vector of the underlying tissue and skeletal structure resistance displayed as a bar graph. As both techniques are directed at enabling a greater understanding of the underlying musculoskeletal structure, questions naturally arise such as:

- If the two methodologies are different, where do the differences lie?
- If the two methodologies are similar, where do the similarities lie?
- What information presented by either method is uniquely different from the information presented by the other method?
- Does the information presented by one method complement the information provided by the other and, if so, how?

This study represents an attempt to answer these questions.

RESEARCH DESIGN

As part of the normal new patient intake procedure, twenty-five patients were assessed using standard x-ray analysis of the cervical spine in neutral and flexion. The x-ray films were analyzed to determine the location of gross discontinuities of the curvature of the cervical spine and the existence of bony growths or osteo-arthritis. In addition to the x-ray examination, CFI scans were used to provide an independent assessment of fixations in the patient's cervical spine.

Discontinuities of spinal curvature, bony growths and osteo-arthritis were used as the criteria in the analysis of the x-ray films. The identification and use of these criteria as elements in the diagnosis and treatment of musculoskeletal complaint follows long-standing practice in the chiropractic profession.[2] [3] These structural changes in the anatomy and pathology of the spine are thought to form an important component of the underlying cause of patient complaints.

Arthritic involvement in and around the vertebrae was judged to be present if the edges of vertebrae were not sharply defined and diffuse shadows extended from the vertebrae into the joint space.

After the x-ray films were obtained, each patient was further evaluated with the Sense Technology PulStarFRAS. This instrument produces an objective and repeatable analysis of the compliance of the cervical spine by challenging each vertebral segment with a low energy impulse and measuring segmental resistance to motion or compliance. Differences in compliance of greater than 15 to 20% observed between two spinal segments were taken to indicate the presence of joint fixation.

Patient Selection

Twenty-five patients were selected for participation in the study from new patients seeking chiropractic care at a private clinic. Only patients who had not previously been seen by the clinician were chosen. No distinction was made on the basis of the patient having obtained chiropractic care elsewhere prior to their visit to the clinic or on the basis of presenting nature of complaint, gender, age, or diagnosis etc.

Clinical Protocol

The first step in the intake procedure was the development of a thorough patient history. After the completion of his/her history, the patient was advanced to the next stage of analysis, which includes x-ray and structural compliance evaluations. The x-ray evaluations performed on each patient were part of the normal intake process of the clinic and are performed to rule out the existence of fractures and underlying disease processes as well as to identify structural abnormalities. This study reports the findings of this stage of analysis.

For lateral cervical x-ray, the patient was in a standing position with the neck in flexion and the chin tucked to separate the upper cervical vertebrae.

For the CFI analysis, the patient was seated in an erect position. The patient's head was placed in flexion with the chin flexed toward the chest. This position places the patient's cervical area at the limit of passive motion. In this position, any fixations in flexion come into play and are more easily detected by the instrumentation.

A 30mm dual probe attachment to the PulStarFRAS was used to perform the analysis of compliance in the cervical area. The probe of the impulse head was placed at the level of each of the cervical vertebrae with the major axis of the impulse head parallel to the joint facets and the dual tips at an equal distance from the centerline of the spine. The analysis was started at the junction of Occ/C1. The contact point for the cervical vertebra (C1- C7) was the lamina pedicle junction with the angle of the impulse head parallel to the joint facets.

INSTRUMENTATION

X-ray Equipment

The x-ray equipment used in the study was a Model 325 manufactured by Transworld equipped with automatic exposure adjustment.

PulStarFRAS

The PulStarFRAS applies a fixed low energy mechanical impulse to the underlying tissue and measures the response of the tissue and underlying bony structure to the impulse. A site of low stiffness (high compliance) exhibits a lower response when compared to areas of high stiffness (low compliance). The theory of operation and repeatability of the instrument have been described in detail elsewhere.[4] The compliance (stiffness measurements) are performed by the clinician using the impulse head of the instrument. Pressing the instrument against the patient at the site of measurement creates a preload between the instrument and the patient. When the preload reaches a preset value, the mechanical impulse is generated. By establishing the same preload at each site of measurement and using the same excitation energy for each measurement the instrument obtains a precise, repeatable measurement of the underlying compliance.

Normally, the clinician obtains a series of measurements, corresponding to the area of interest in the spine, i.e. measurements in the cervical, thoracic or lumbar areas. The resulting measurements are displayed as a bar graph normalized to the largest response obtained in the area of interest.

This display of the relative compliance of the spinal segments of interest may be thought of as an instrumented and objective palpation. During manual palpation, the clinician is testing for differences in response along the spine. Likewise, the instrument produces a graph of the relative compliance of the spine that highlights the differences in compliance from segment to segment, mimicking the manual palpation process but with much greater measurement accuracy and repeatability than is possible with manual palpation. In addition, the graphs express the differences from segment to segment as percentage changes.

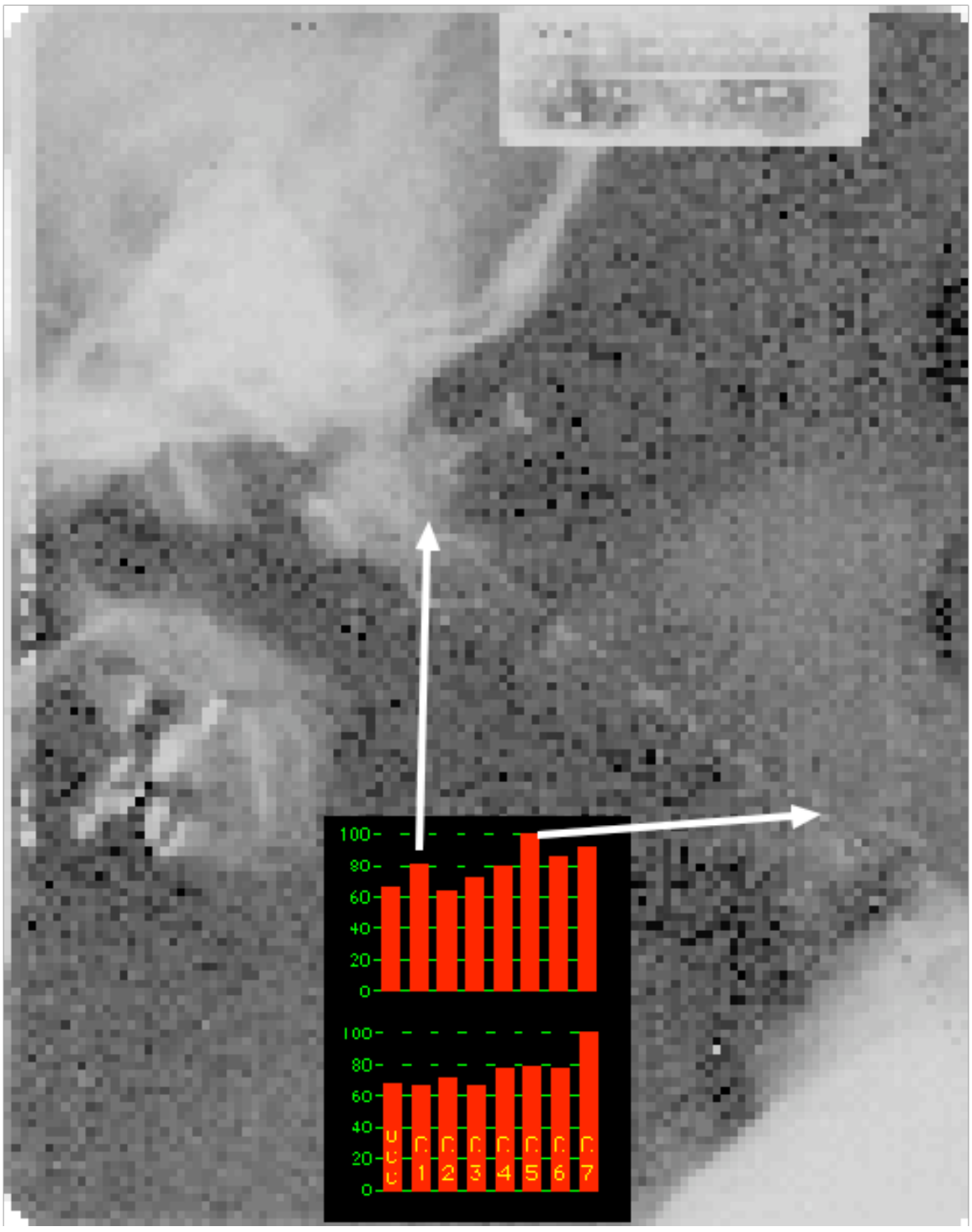
Typically, intervention in the form of joint mobilization or adjustment is performed when deemed appropriate by the clinician. CFI may be used to evaluate the effects of correction on spinal compliance by performing a post CFI scan[5].

ANALYSIS

The analysis was performed by first reviewing and categorizing each x-ray image by type and location of cervical abnormality. Discontinuities in the curvature of the cervical spine were located by observing discontinuities or "kinks" in George's Line. A difference of greater than 15 to 20%[6] between any two sites tested using the PulStarFRAS was taken to be evidence of a fixation at that site.

The authors independently performed each analysis. That is, each examiner was blinded to the results of the other examiner during the analysis. The second author performed the x-ray analysis while the first author performed the analysis of CFI results. Prior to the compilation of results and comparison of data, the data were reviewed for consistency by both authors independently.

RESULTS



Example X-ray with CFI Reading Showing Fixations at C1 and C5 Prior to Mobilization

Table of Comparative Results

	X-ray Analysis			Agreement	
Patient	Cervical Curve Discontinuity	Osteo-arthritis	CFI Analysis	Cervical Curve Discontinuity	Osteo-arthritis
1	C4-C5		C4-C5	y	
2		C3-C4 Spur at C4 & C6	C3-C4, C6, C7		y
3	C5	C5-C6	C4-C5-C6 Stair-step Up	y	y
4	C2, C6		C5	y	
5	C4		Occ-C1-C2, C6-C7	n	
6	C4		C3-C7 Stair-step Up	y	
7		C4-C5	C5-C7		y
8		C4-C5	C4-C6, C7		y
9		C5-C6	C5, C6, C7		y
10	Normal	Normal	Occ-C1, C6-C7	n	n
11		C3-C4-C5-C6-C7	C3-C4-C5		y
12	Normal	Normal	Normal	y	y
13	C4-C5	C5-C6-C7	C5-C6-C7	y	y
14	C5-C6	C5-C6	C2, C5-C6	y	y
15	C5-C6	C4-C5-C6	C6-C7	y	y
16	C2-C3-C4		C6-C7	n	
17	Military Neck		Normal	n	
18	C5	C5-C6	Occ-C1, C6-C7	y	y
19	C5-C6		Occ-C1-C2, C4-C5-C6	y	
20	C5-C6	C5-C6	C5-C6-C7	y	y
21	C5		C1-C2, C5-C6-C7	y	
22	C5-C6	C5-C6	C2, C5-C6-C7	y	y
23	C4	C3-C4-C5	C3-C4, C5-C6	y	y
24	C2, C5	C5-C6	C3-C4, C5-C6-C7	y	y
25	C4-C5-C6-C7	All	C3-C4-C5	y	y

In general there appears to be a very high degree of similarity between the results of the x-ray analysis and CFI analysis. The data in the above table were analyzed using Kendall's Coefficient of Concordance[7] . Using this measure, sites identified on x-ray films as having obvious arthritic involvement were identified as fixated in the CFI analysis with a coefficient of .74 (p=1.02E-05). Sites identified on x-ray as having obvious cervical curve discontinuity were identified as fixated in the CFI analysis with a coefficient of .76 (p=1.92E-05). The overall agreement between the CFI analysis and the combination of the two x-ray analyses is .74 (p= 1.02E-05).

The major difference between the two methods of analysis lies in the specificity in identifying the underlying cause of fixation. X-ray analysis can distinguish between

discontinuities in spinal curvature and the occurrence of arthritic involvement in and around joints while the CFI analysis cannot. In addition, the CFI analysis includes responses due to soft tissue abnormality that cannot be observed with x-ray[8].

DISCUSSION

The chiropractic profession has used x-ray analysis as an adjunct to the analysis of spinal dysfunction since 1910 when B. J. Palmer purchased an early model for the Palmer School of Chiropractic. The primary use of x-ray analysis of the spine is the examination of the symmetry of the spinal structure as well as the detection of abnormal pathology or disease process.[9]

The primary advantage of x-ray analysis is that the clinician is afforded a direct view of the skeletal structure and the relationship of its components. In addition and most importantly, its use over the last 89 years has resulted in the development of a substantial body of interpretative methods and reference works that make the acquisition of skills and productive use of x-ray accessible to the practitioner.

While x-ray views may in some instances be able to measure the relative range of motion available between vertebral segments, x-ray cannot display or measure the relative stiffness or resistance to motion between vertebral segments. This important information is easily obtained with CFI analysis

Primary among the disadvantages of x-ray analysis is the fact that the effects of exposure to x-rays are cumulative; that is, each exposure adds to the risk of irreversible tissue and cell damage. Other disadvantages include geometric distortion due to projection artifacts, distortion due to patient positioning, unrecognized anatomic variation, inappropriate location of standard reference points, and subjective interpretation.

Because of the hazards to the patient that may accrue from multiple exposure, x-ray analysis may not be used as a means of monitoring patient progress on each visit.

A major advantage of CFI analysis is the fact that because it does not use ionizing radiation, the analysis can be used on each patient on each visit. Another advantage of CFI analysis is that it provides a direct measure of joint fixation, which is the primary rationale for intervention and patient treatment. A third advantage of CFI analysis is that the data presented to the clinician is objective and repeatable. In addition, the CFI compliance readings are reflective of the underlying skeletal musculature as well as structural components.

One feature of CFI analysis is that it does not distinguish between arthritic involvement and structural discontinuity as underlying causes of joint fixation. This does

not constitute a problem since the theories of manipulation do not distinguish between these causes in guiding correction.

CONCLUSION

Clinicians who use CFI compliance readings as an adjunct measurement as well as other means of monitoring patient progress have raised questions regarding the relationship between CFI analysis and x-ray analysis of the spine. The results of this study show a high degree of correlation between x-ray analysis and CFI in findings of discontinuities of spinal structure and in observation of evidence of osteo-arthritis.

In addition, due to the nature of the procedure, the CFI analysis is sensitive to soft tissue differences and the scans reflect the existence of muscle spasm as well as structural or arthritic abnormalities.

The authors are not suggesting that CFI analysis be used in lieu of any other analysis that has been found to be of value in patient management. This is especially true of x-ray analysis which is uniquely capable of visualization of underlying bony structure including fracture and osseous disease process. CFI analysis provides another window through which the clinician may add to the current knowledge of the state of the skeletal system.

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